Spectral and Radiometric Issues for Level 1C

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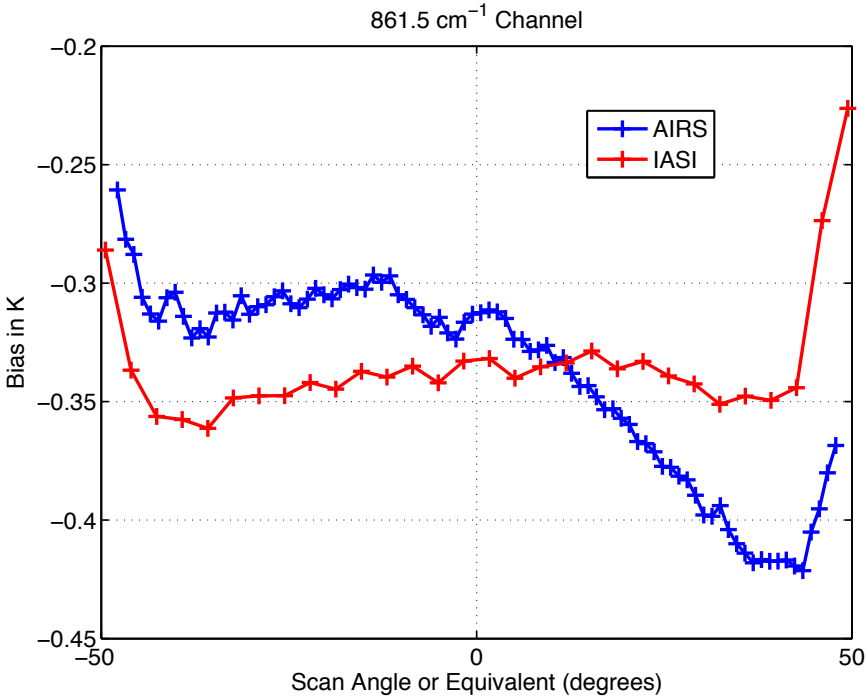
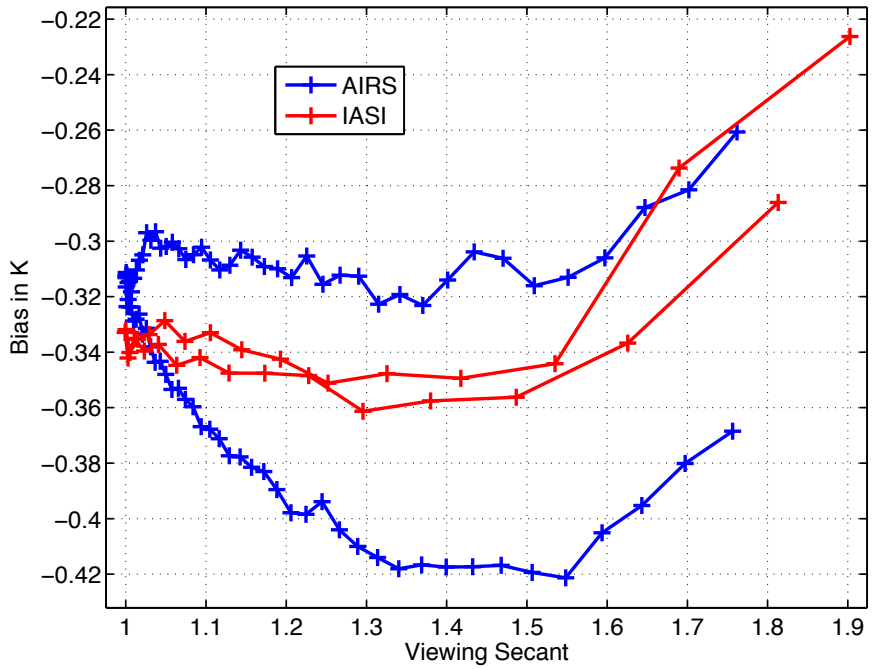
Overview

- Science using AIRS is pushing below the 0.03K level!
- Is the instrument and the AIRS Radiative Transfer Algorithm up to this?
- Examine AIRS biases relative to ECMWF versus viewing angle. Absolute errors remain uncertain, but may highlight other errors.
- Assimilation community has been doing this forever...

861 cm^{-1} Window Channel Bias vs Viewing Angle

Left: Versus scan angle, Right: Versus secant of viewing angle





- Window channel, don't expect bias linear in secant.
- Note asymmetric behavior of AIRS.
- IASI flat bias until very high angles.
- AIRS asymmetry related to polarization?

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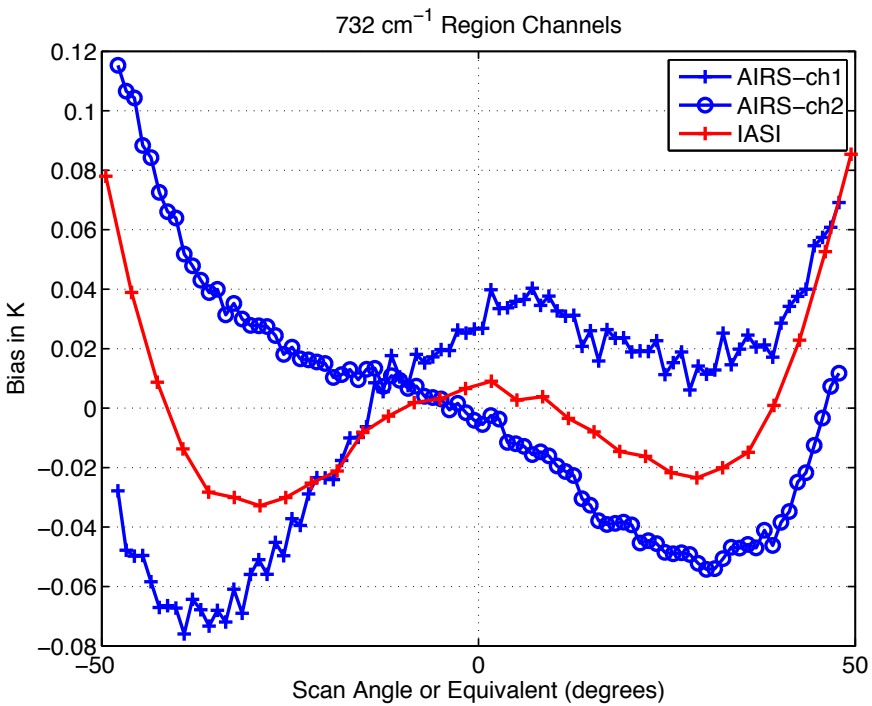
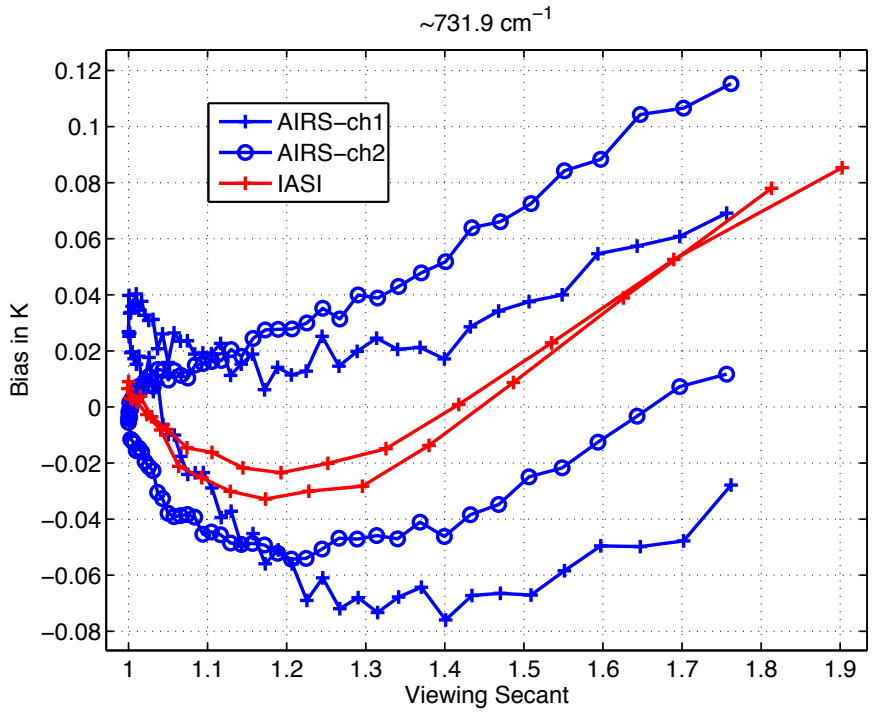
732 cm^{-1} Opaque Channel Bias vs Viewing Angle

Left: Versus scan angle, Right: Versus secant of viewing angle





- AIRS ch1 and ch2 are on different sides of a spectral line
- AIRS has both symmetric and anti-symmetric behavior
- IASI almost symmetric
- AIRS asymmetry is xtrack frequency dependence

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Fitting Function for Bias

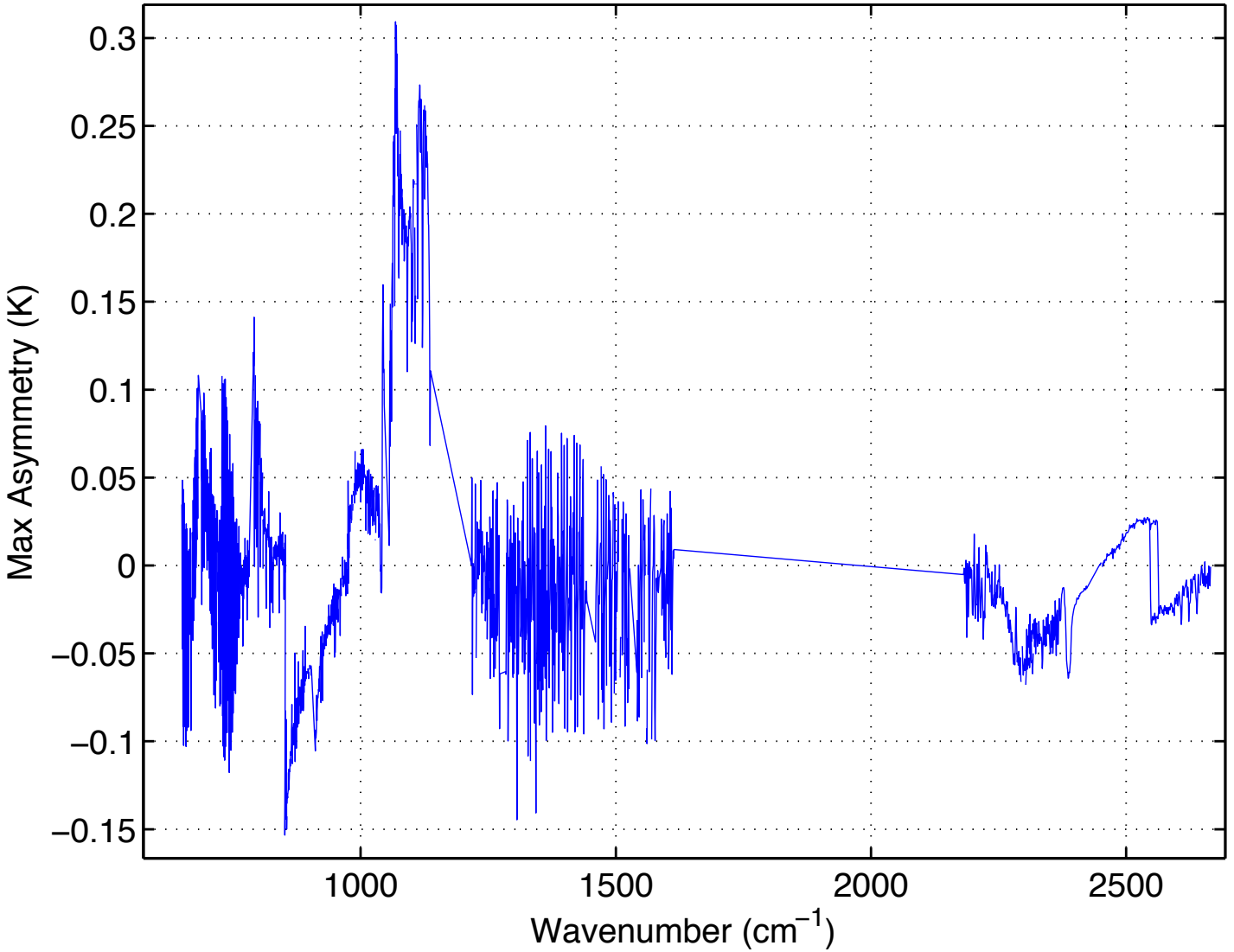
$$Bias(xtrack) = a_1 + a_2 \times (secant - 1) + a_3 \times (secant - 1)^2 + a_4 \times scan\_angle$$

where the Bias is relative to ECMWF for a large statistical set of clear ocean spectra (0-25 Deg. North), secant is the secant of the satellite zenith angle, and scan_angle is the AIRS scan mirror angular position.

1. a_1 is the nadir bias (scan_angle == 0).
2. $a_{2,3}$ account for viewing angle bias, mostly spectroscopy, symmetric
3. a_4 introduces a linear asymmetry term to the bias

$a_1 - a_2$ should only contain instrument and profile errors, no spectroscopy errors (for opaque channels). Note: a_3 is small.

a_4 Term: Linear asymmetric bias term



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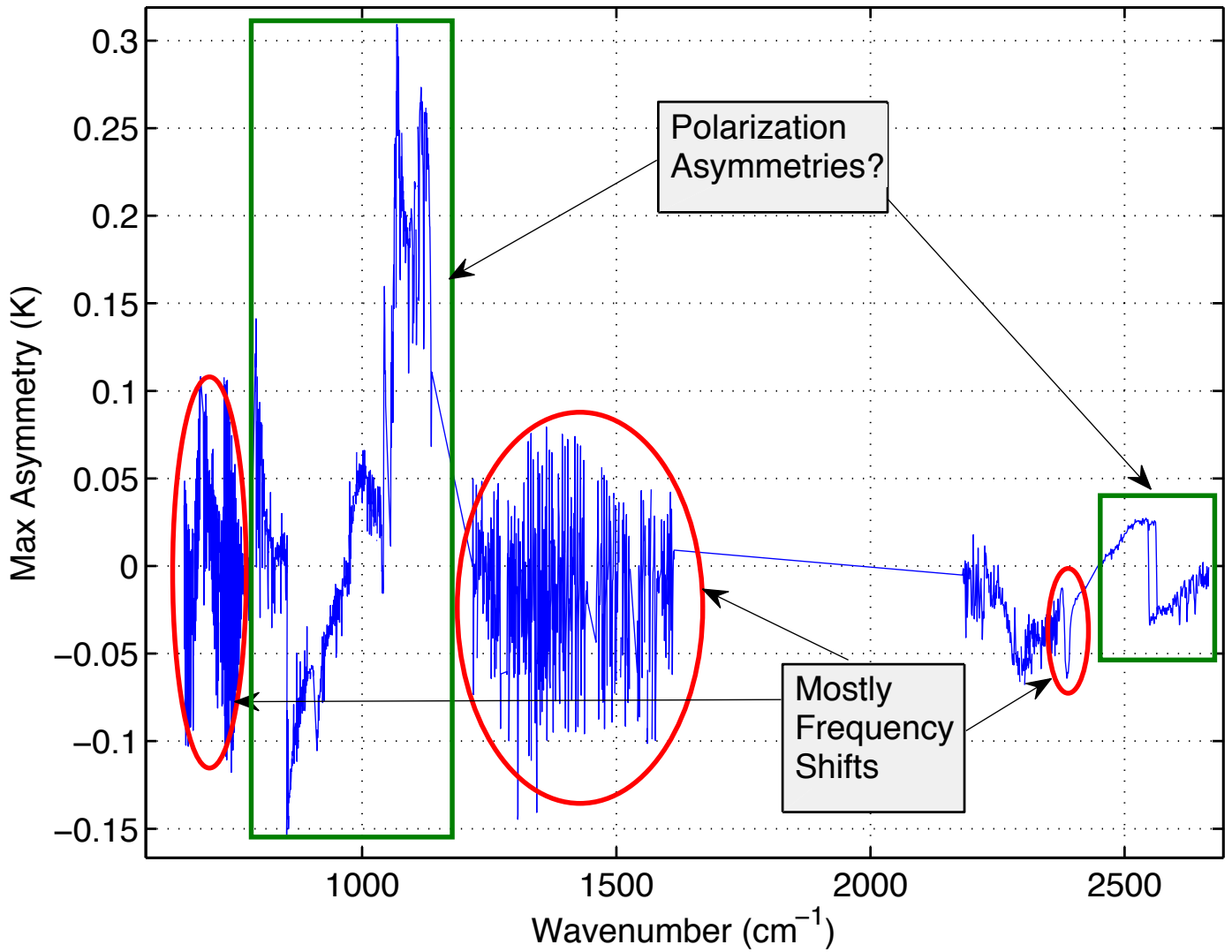
a_4 Term: Linear asymmetric bias term



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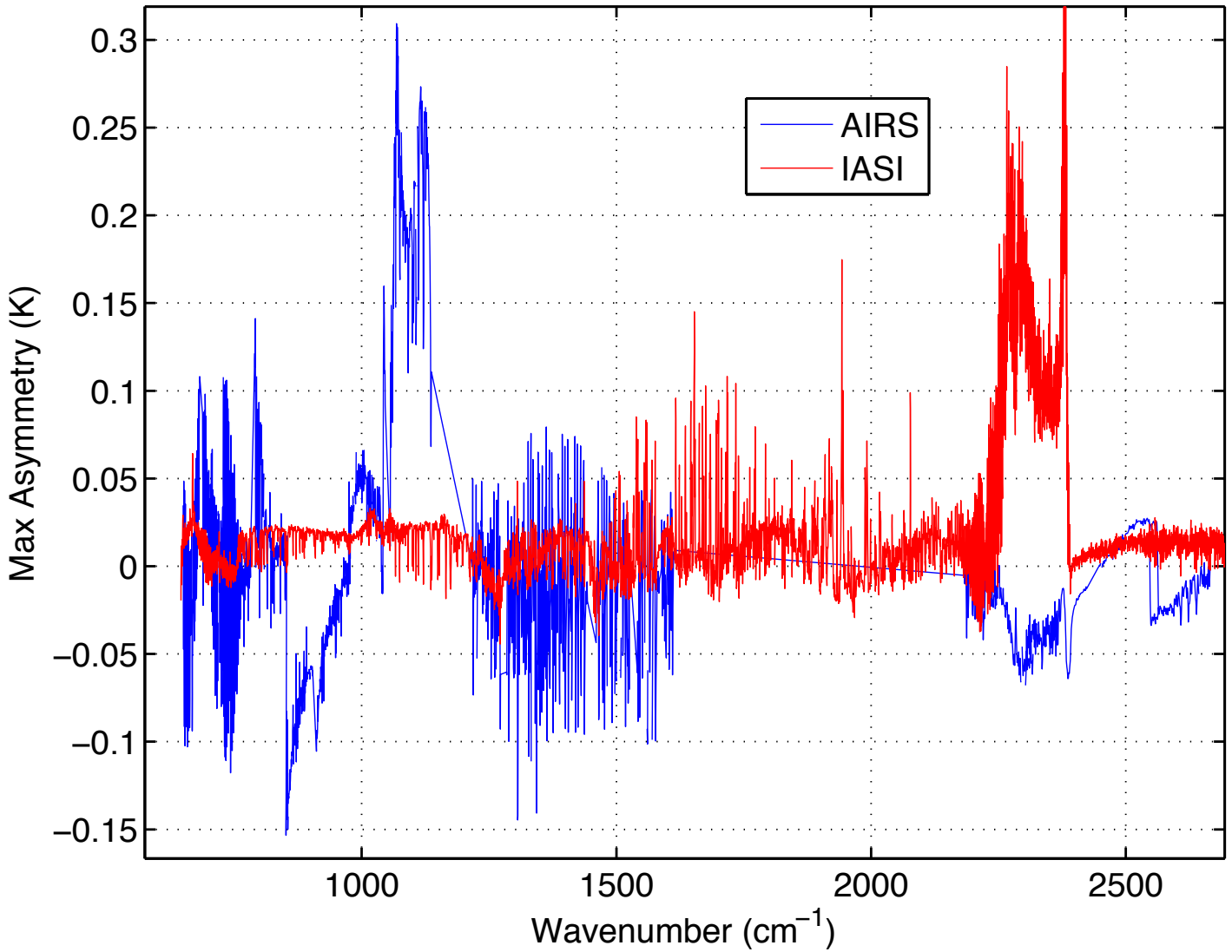
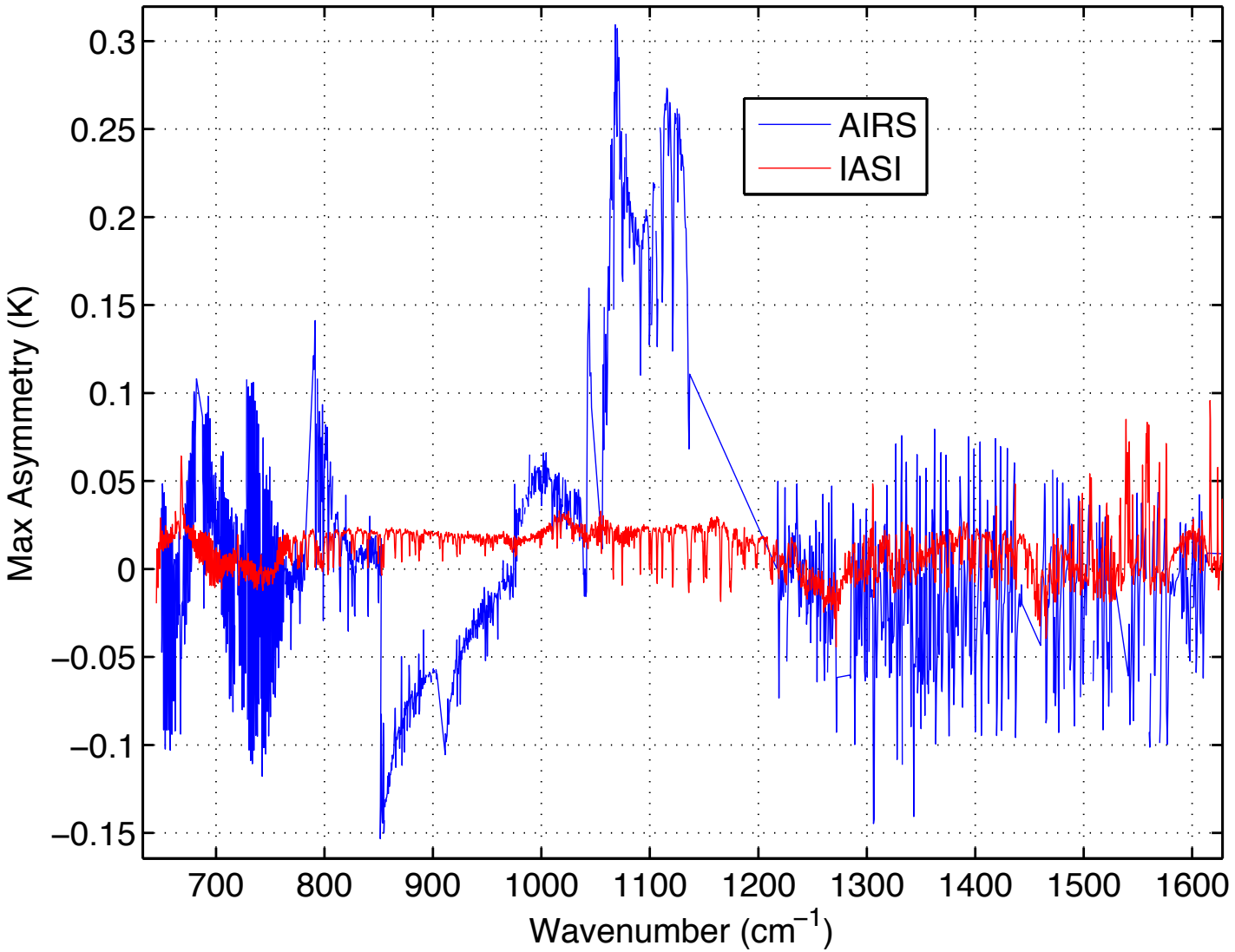
a_4 Term, Now include IASI



a_4 Term, Now include IASI, ZOOM



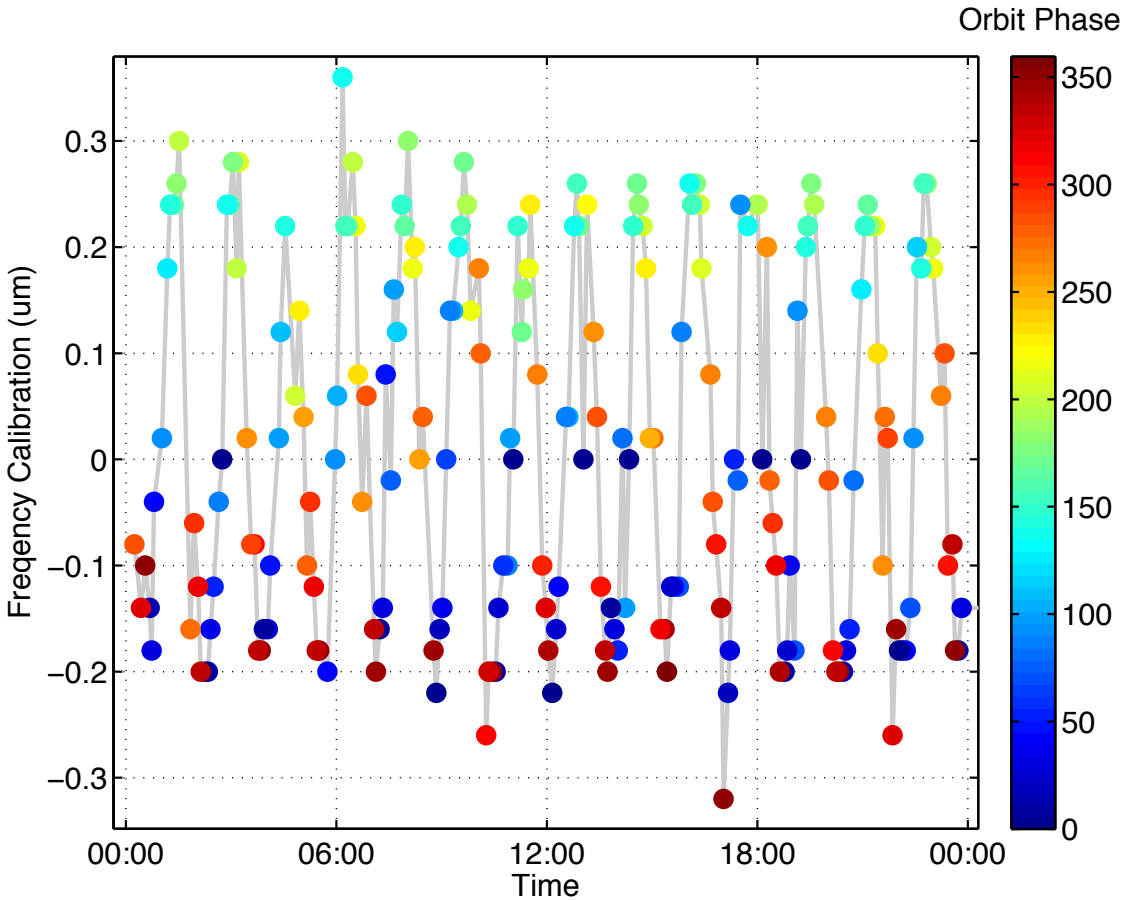
What is causing these asymmetric biases?

Clue: Not seen in IASI!

- Larger biases in window regions probably related to polarization. AIRS has aluminum overcoat mirror, IASI mirror is gold
- Closer examination of opaque channel biases reveals that this “hash” is a frequency shift!
- Evan Manning quickly postulated this was a Doppler shift, earth’s rotation relative to AIRS changes sign at nadir.
- IASI does not exhibit the Doppler shift due to METOP “yaw steering” and image motion compensation?
- All previous frequency calibration measurements used granule averages!

Re-examination Frequency Calibration

Now separate calibration by xtrack position.



This is a one-day frequency calibration with orbit phase encoded by color. Effect largest at equator (Orbit phase == 0, 180, 360). Consistent with Doppler effect.

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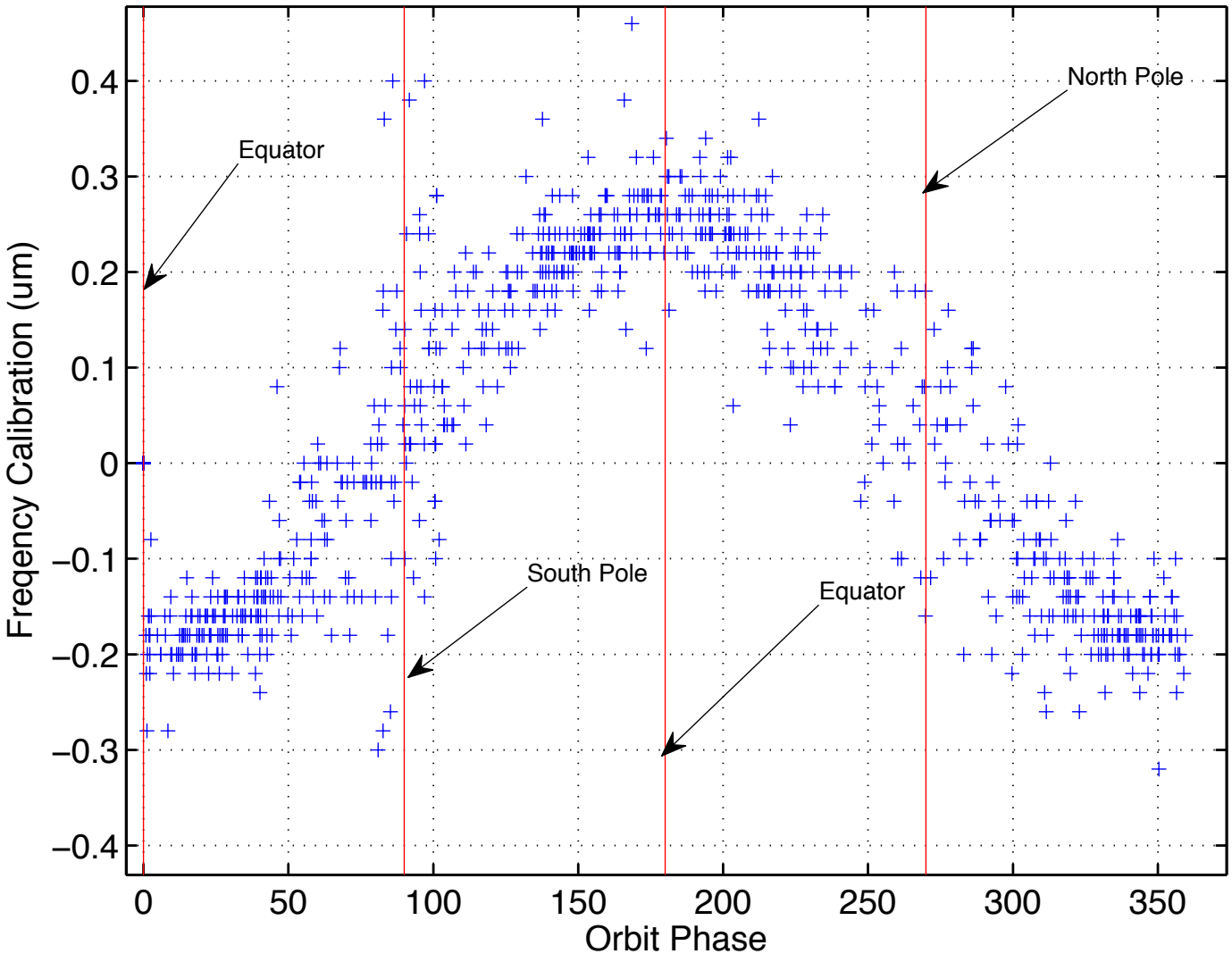
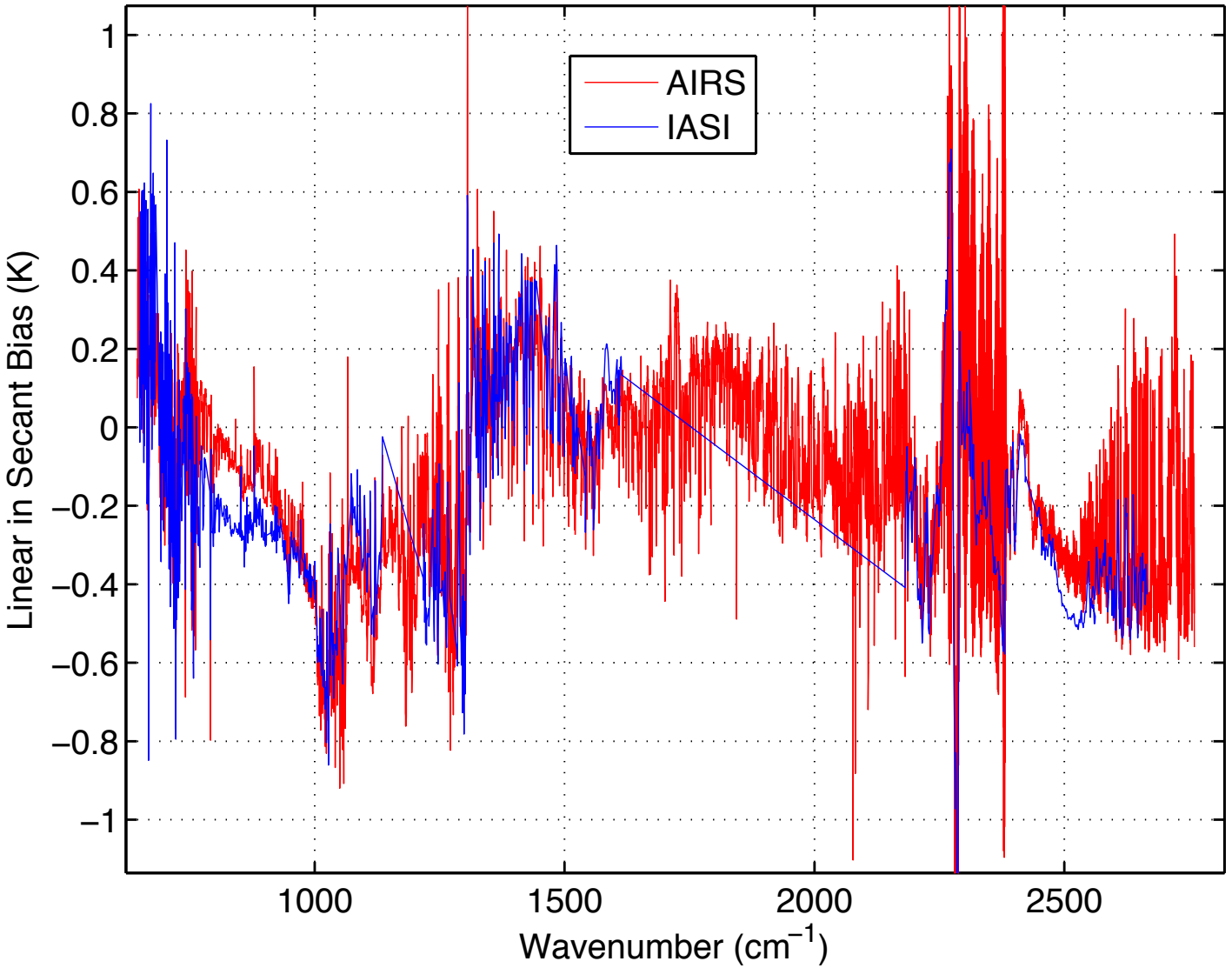
Another View: Frequency Calibration vs Orbit Phase



Examine other Bias Coefficients: a_2

Linear secant term: Spectroscopy Errors.



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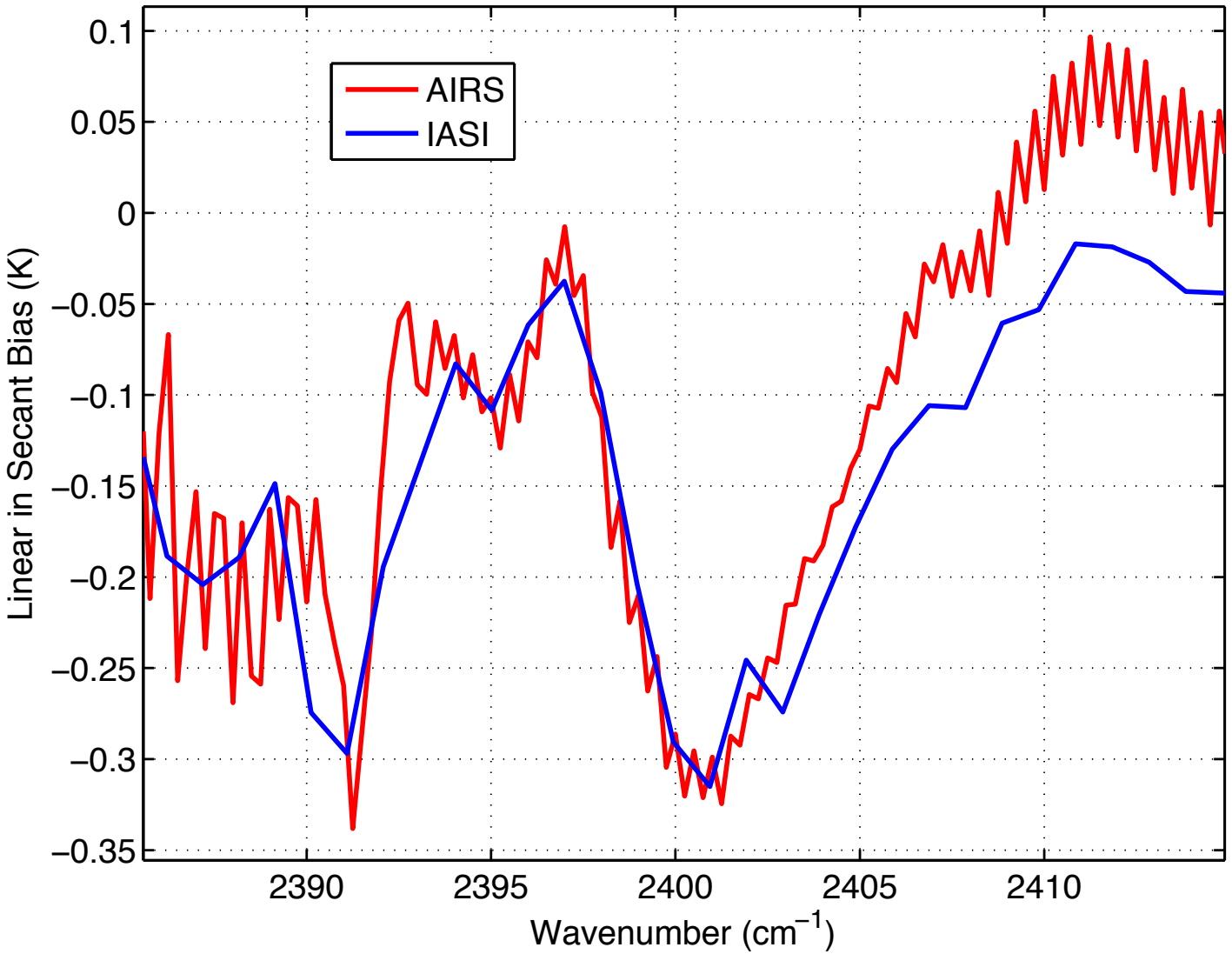
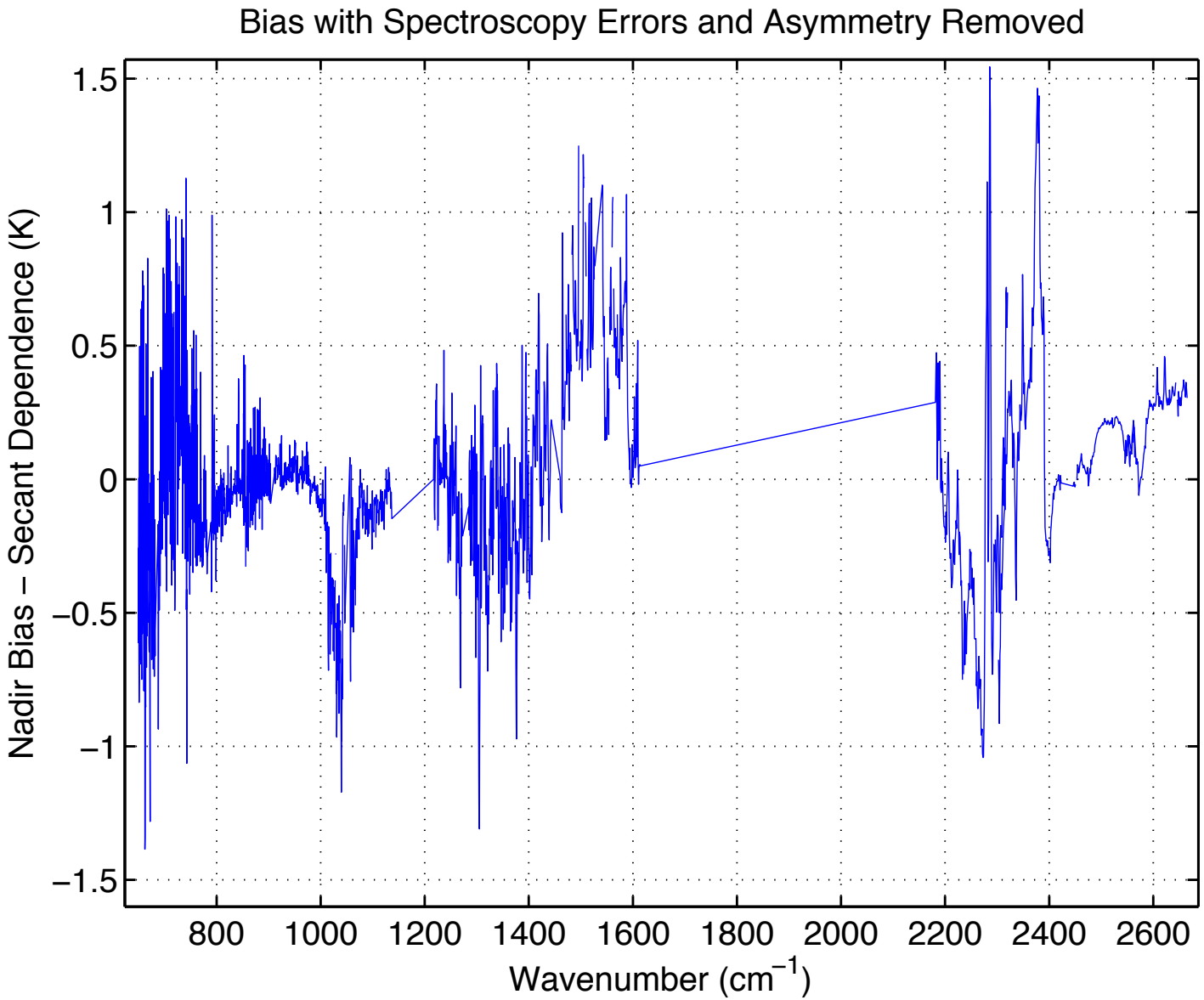
Examine other Bias Coefficients: a_2, ZOOM



$a_1 - a_2$ Removes Spectroscopy, Asymmetric Errors

This term contains instrument and ECMWF profile errors.



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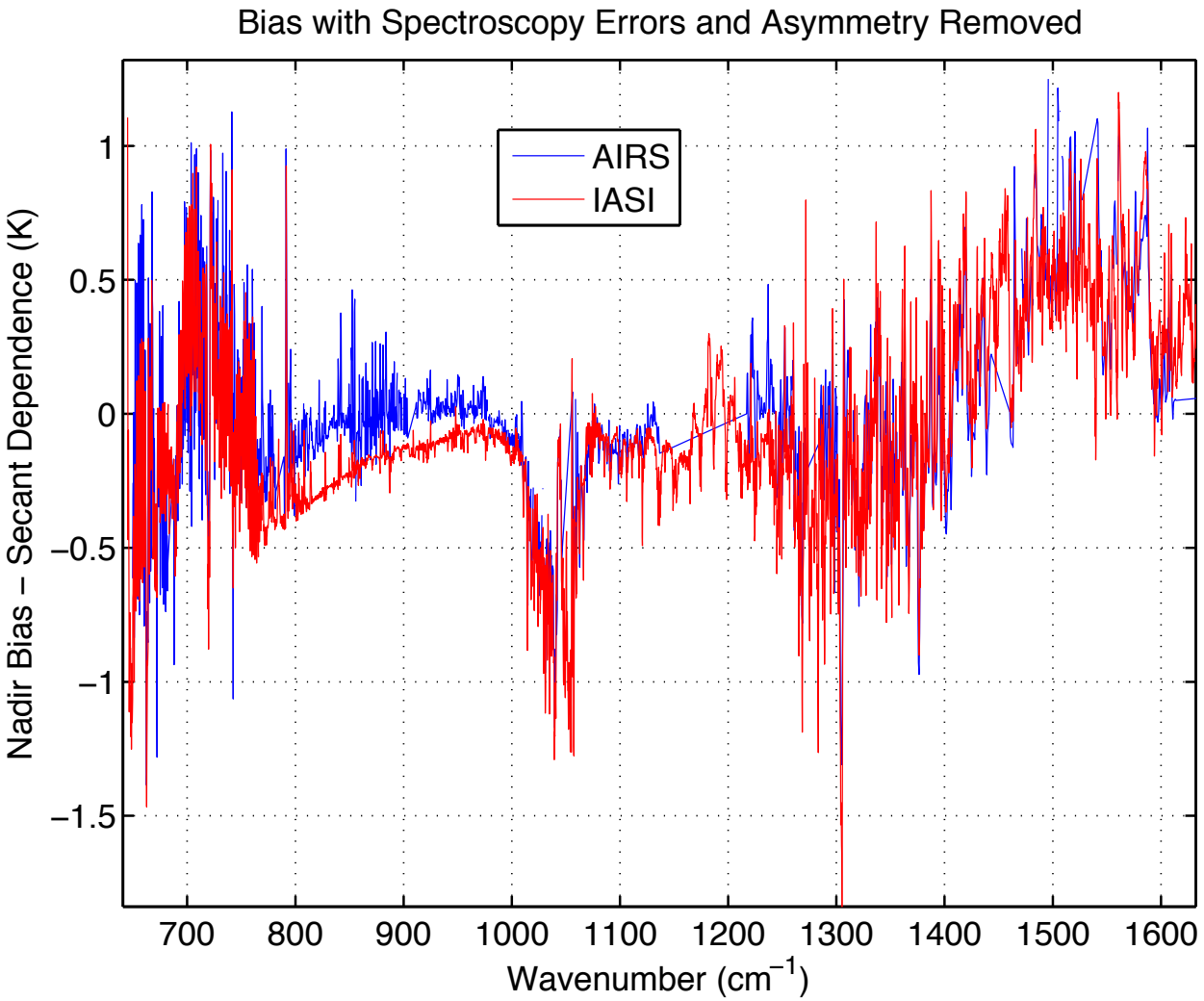
$a_1 - a_2$, now with IASI

IASI and AIRS similar, implies profile errors.



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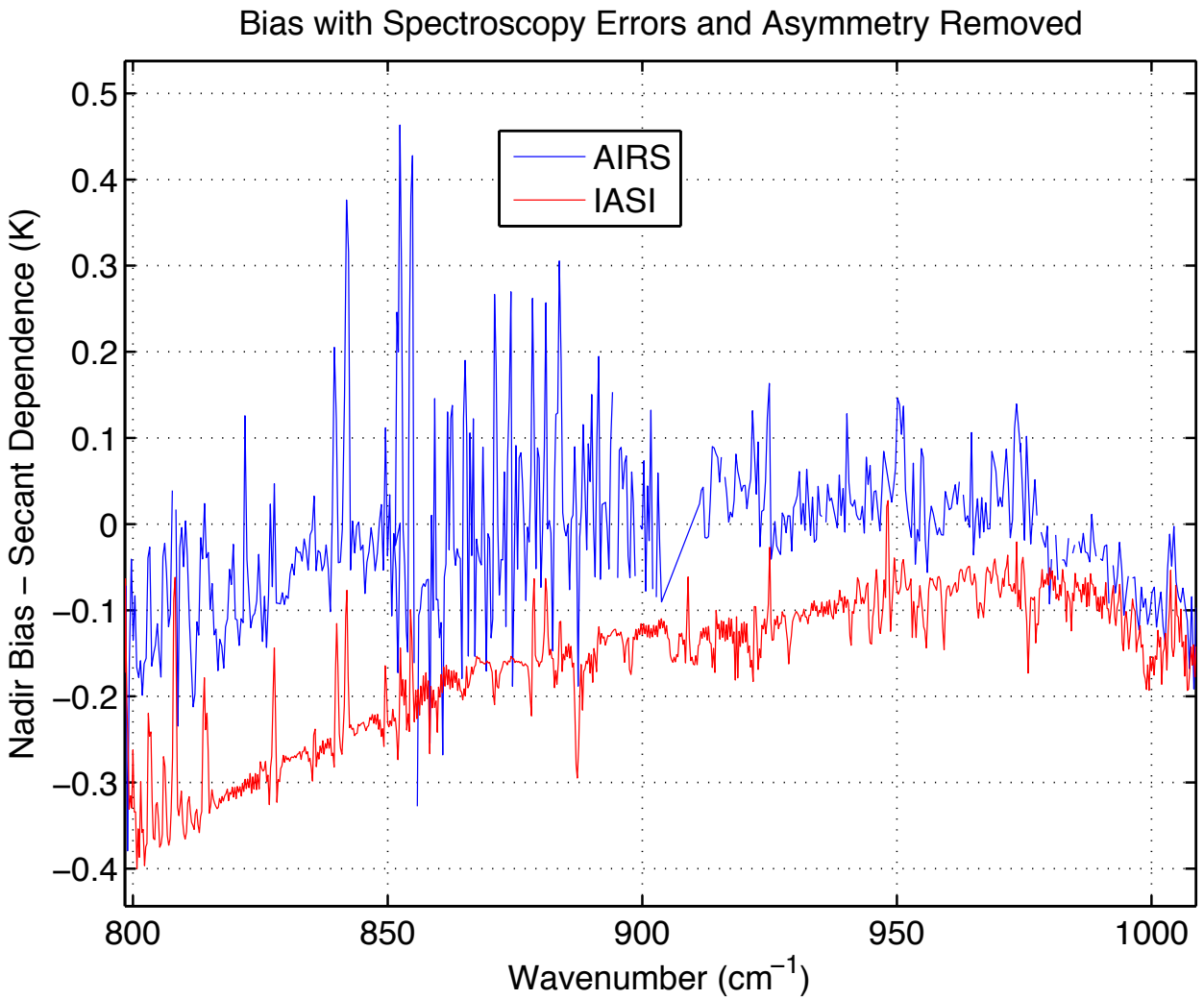
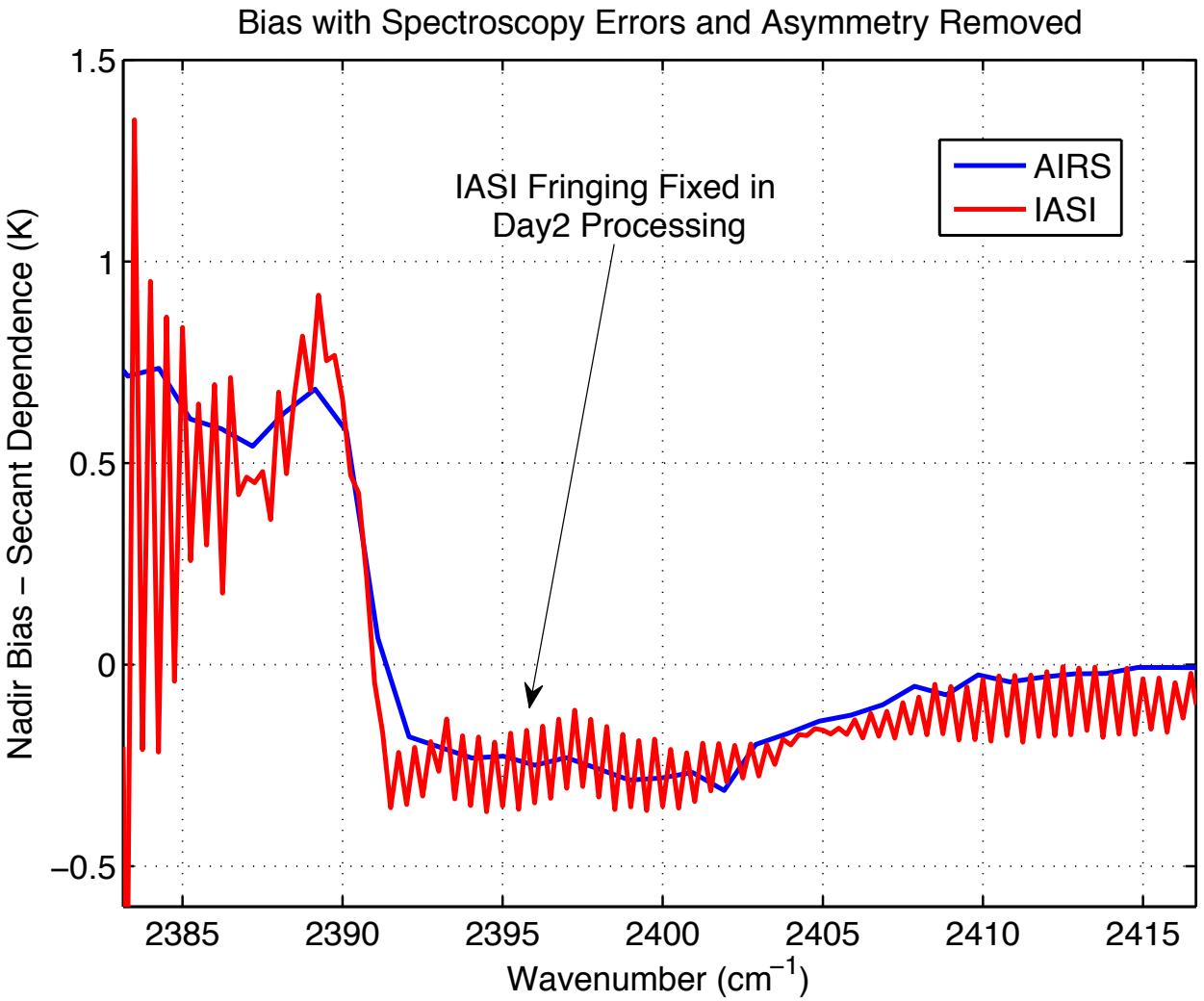
$a_1 - a_2$, Zoom in Window Region

A/B Calibration variation shows up, 850-900 cm^{-1}.



$a_1 - a_2$, Zoom in 4.3 μm R-branch

Very different form than secant error. More consistent with profile error.



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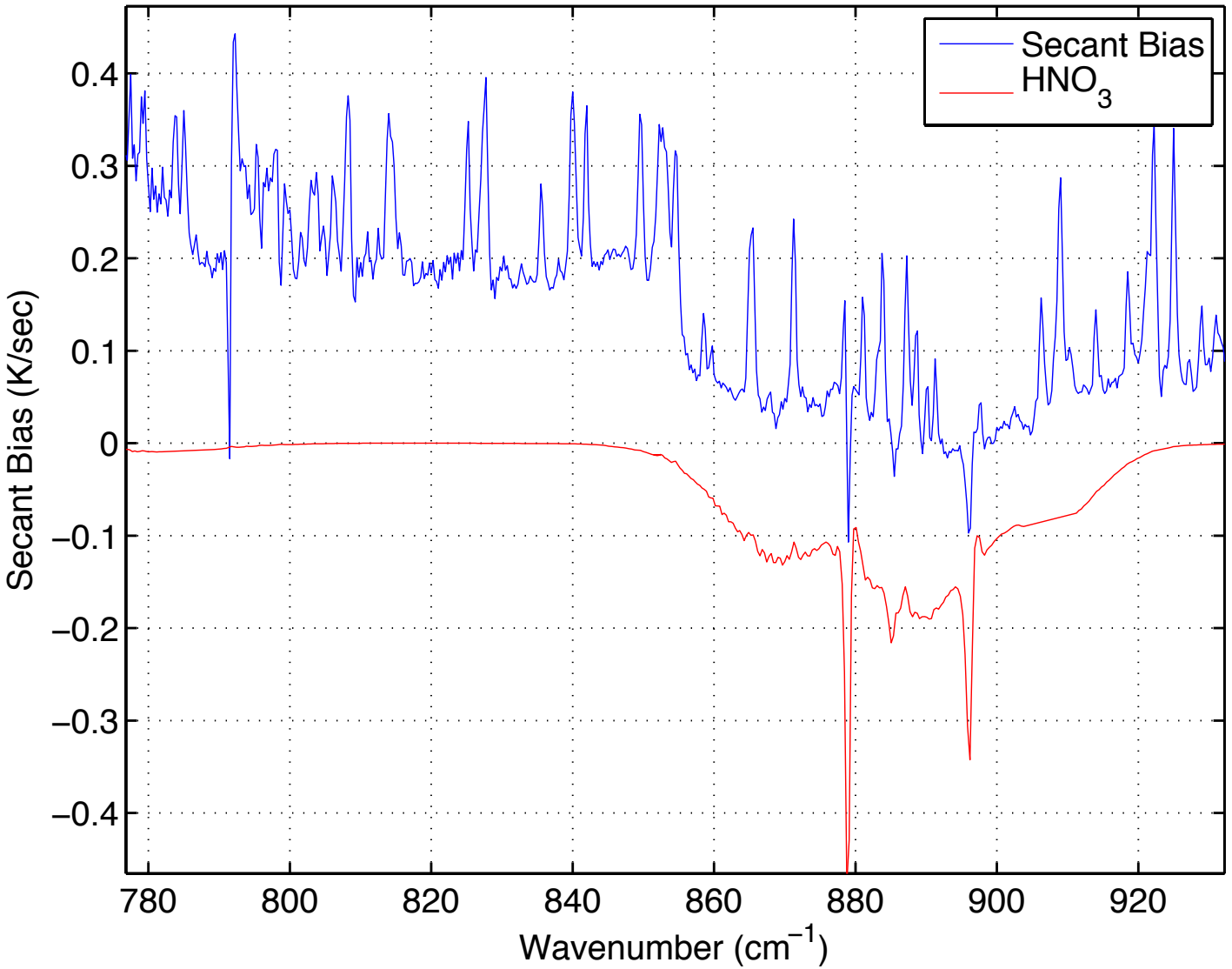
IASI Secant Bias over NH Land

Note HNO_3 and dip near 790 cm^{-1}.



Conclusions

- AIRS radiative transfer algorithm (RTA) has secant angle biases of up to 0.6K. Needs to be fixed.
- AIRS has instrumental asymmetric cross-track biases of up to ~0.1-0.2K. Probably polarization?
- Doppler effect also contributes to biases, this one should be easy to fix.
- Examination of the secant dependence of the AIRS biases relative to ECMWF has proven very fruitful.
- Biases that we can attribute to AIRS or the RTA are significant relative to the more demanding AIRS applications (CO_2, for example).